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Mo-Sci Specialty Products L.L.C.

Products

- AccuRods
- Bond Line Spacers
- Duraspheres
- IdentiSpheres
- Metaspheres

Product Info

- Data Sheets
- MSDS

Sales Contact

- Joy Schmit, Director of Sales, (573) 364-2338, jschmit@mo-sci.com

Engineering Contact

- Ted Day, President, (573) 364-2338, tday@mo-sci.com

News

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- Customer Survey

Quality

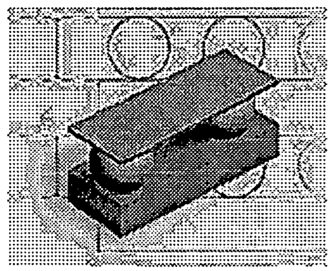
- Quality Manual

bond line spacers class VI

Mo-Sci has extensive experience in manufacturing glass microspheres and fibers. We also develop glass compositions whose properties are tailor-made to satisfy particular applications. If you need a special glass frit, glass microsphere spacer or desire further information, contact our office and one of our engineers will be happy to discuss our products and services with you.

bondline spacers

- Spacer Grade Glass Microspheres (SGGM) are manufactured to provide highly accurate bondline spacing. These microspheres are supplied with greater than 90% true spheres and greater than 95% in the specified size range. Sizes range from 38µm±7% to 850µm±5%.
- Spacer Grade Glass Microspheres are highly spherical, free of odd shapes and angular particles. Their high sphericity, close size tolerances and high mechanical strength and chemical durability make them ideal for all applications that require these high-grade standards.
- Spacer Grade Glass Microspheres can withstand temperatures up to 830°C which makes them ideal for high temperature applications.
- Spacer Grade Glass Microspheres are presently used in gas plasma displays, automotive mirrors, electronic displays, flip chip technology, filters, sporting goods equipment, calibration standards and transformer manufacture (see application notes).
- Special surface treatments can be given to the microspheres to fit almost any need.



- A number of standard glass compositions are available (soda lime, barium titanate, borosilicate) as well as custom-made glass compositions.
- No special handling is needed with our glass microspheres, since they contain no toxic elements. The CAS Registry Number is: 65997-17-3.

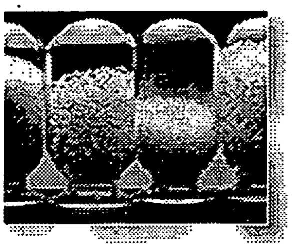
selected properties

- Density from 2.2 to 4.5 g/cm^3
- Refractive Index (n_D) 1.47 to 2.10
- Thermal Exp: 40 to 100 x 10^{-7} cm/cm/°C
- Thermal Softening: 400 to 830°C
- 90% Survival crush strength: ~40,000 psi
- Excellent chemical durability

Mo-Sci Corporation -- Big Company Capability, Small Company Flexibility.

The Company Designed to Meet Your Needs!

Potters Industries Inc.
an affiliate of PQ Corporation



Spacer Application Glass Beads

Potters Industries supplies solid glass spheres used to establish bond line thickness in adhesive bonding. These products meet the requirements of Hughes standard HMS20-1776B and SCGMS-53004.

Composition	Soda-lime glass
Appearance	Colorless sphere
Specific Gravity	2.5
Refractive Index	1.51
Softening Point	704°C

Product Specifications: Spacer Application Glass Beads
MSDS: SPHERIGLASS® Solid Glass Spheres

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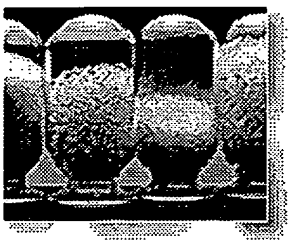

Spacer Application Glass Beads

Potters Industries supplies solid glass spheres used to establish bond line thickness in adhesive bonding. These products meet the requirements of Hughes standard B185712, HMS20-1776B, and SCGMS-53004.

Composition	Soda-lime glass
Appearance	Colorless sphere
Specific Gravity	2.5
Refractive Index	1.51
Softening Point	704°C

Product Specifications: Spacer Application Glass Beads
MSDS: SPHERIGLASS® Solid Glass Spheres

SPHERIGLASS

SOLID GLASS SPHERES

Potters Industries Inc.
an affiliate of The PQ Corporation

P.O. Box 840
Valley Forge, PA 19482-0840 USA
Telephone: (610) 651-4700 ■ Fax: (610) 408-9724
Web site: www.pottersbeads.com

Spacer Application Glass Beads

Potters Industries offers a wide range of specialized glass beads, specifically designed for controlling bond line thickness. The products meet the requirements of Hughes standard HMS20-1776B and SCGMS-53004.

Composition:	**Soda-lime glass**
Appearance:	**Colorless sphere**
Specific Gravity:	**2.5**
Refractive Index:	**1.51**
Softening Point:	**704°C**

Available Size Information

Potters Product Code	Hughes HMS20-1776 SCGMS-53004 Type	Nominal Maximum Diameter(Inch)	*90% of Product Within DiameterRange of: (Inch)
602578	I	.0234	.0197-.0234
602579	II	.0165	.0139-.0165
602580	III	.0117	.0098-.0117
602581	IV	.0098	.0083-.0098
602582	V	.0070	.0059-.0070
602583	VI	.0049	.0041-.0049
602584	VII	.0041	.0035-.0041
602585	VIII	.0035	.0029-.0035
602586	IX	.0029	.0025-.0029
602587	X	.0025	.0021-.0025
602588	XI	.0021	.0017-.0021
602589	XII	.0017	.0015-.0017
602590	XIII	.0015	<.0015

Minimum Order: 2 pounds North America, 5 pounds (2.26 kilograms) all exports.
Freight Terms: FOB Canby, Oregon
Packaging: 1 Pound Jars, 5 Pound Cans, or 40-50 Pound Pail

These are laboratory produced items and lead time is generally three weeks. Exceptionally large orders (over 5 pounds) may be longer. Please check with Customer Service for details.

● As determined by ASTM D-1214 Sieve analysis of glass spheres.

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MATERIAL SAFETY DATA SHEET

SPHERIGLASS ® SOLID GLASS SPHERES

HMIS RATING: 0,0,0

SECTION 1	IDENTIFICATION OF PRODUCT
MANUFACTURER	Potters Industries Inc.
ADDRESS	Southpoint, P. O. Box 840, Valley Forge, PA 19482-0840
24-HOUR EMERGENCY TEL. NO.	610-651-4700
SALES NAME	Spheriglass® Solid Glass Spheres
CHEMICAL NAME	Glass Oxide
COMPONENTS	Soda-Lime Glass
TSCA CAS REGISTRY NO(S)	65997-17-3
DOT HAZARD CLASS	N.A.
DOT SHIPPING NAME	N.A.

SECTION 2	CHEMICAL AND PHYSICAL DATA
APPEARANCE & ODOR	Odorless white powder.
SPECIFIC GRAVITY	2.46 - 2.49 g/cc
SOLUBILITY IN WATER	Insoluble
pH (aqueous liquids only)	N.A.
OTHER CHARACTERISTICS	Softening point 730°C

SECTION 3	FIRE AND EXPLOSION HAZARD DATA
FLASH POINT (°F)	Non-combustible and non-flammable.
FLAMMABLE LIMITS (vapor in air, vol. %)	N.A.
FIRE EXTINGUISHING MEDIA	N.A.
SPECIAL FIRE FIGHTING PROCEDURES	N.A.
UNUSUAL FIRE AND EXPLOSION HAZARDS	None

SECTION 4	REACTIVITY DATA

STABILITY...Stable
CONDITIONS TO AVOID...None
INCOMPATIBILITY (materials to avoid)................Hydroflouric Acid.
HAZARDOUS DECOMPOSITION PRODUCTS....None
HAZARDOUS POLYMERIZATION....................... Will not occur.

SECTION 5	SPILL OR LEAK PROCEDURES
ENVIRONMENTAL HAZARDS	No adverse effects known or suspected. Not an RCRA hazardous substance or OSHA hazardous chemical. Does not contain a listed toxic chemical under SARA Title 111 §302, §304 or §313.
SPILLAGE	Sweep up and discard.
WASTE DISPOSAL METHOD	Landfill according to local, state and federal regulations.
OTHER PRECAUTIONS	Spillage may result in slippery conditions. When transporting material, care should be taken to avoid dusting.

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MATERIAL SAFETY DATA SHEET

SPHERIGLASS® SOLID GLASS SPHERES

SECTION 6	HEALTH HAZARD DATA

HEALTH HAZARDS	Dust in excess of recommended exposure limits may result in irritation to the respiratory tract.
ROUTE(S) OF ENTRY	Inhalation
CARCINOGENICITY	Not listed under NTP, IARC Monographs, or OSHA.
MEDICAL CONDITIONS	Chronic lung conditions may be aggravated by exposure to high concentrations of dust.
EMERGENCY & FIRST AID PROCEDURES	Remove to fresh air
OTHER CHARACTERISTICS	Contains no free silica; all components amorphous/non-crystalline.

SECTION 7	SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION	Use NIOSH approved dust mask or respirator where airborne dust is generated. Observe OSHA regulations for respirator use (29 CFR 1910.134)
GLOVES	None required.
EYE PROTECTION	NIOSH approved safety glasses or goggles.
OTHER PROTECTIVE EQUIPMENT	None required.
PERSONAL HYGIENE	Avoid breathing dust. Avoid contact with eyes. Wash eyes out immediately after contact.
ENGINEERING CONTROL	Local exhaust is recommended for operations that generate nuisance dust in excess of OSHA exposure limits.

SECTION 8	SUBSTANCES FOR WHICH STANDARDS HAVE BEEN SET

COMPONENTS	Glass Oxide, C.A.S. No. 65997-17-3
PERCENTAGE	>99% <1%
OSHA EXPOSURE LIMIT	Nuisance Dust: OSHA PEL 15 mg/m^3, ACGIH TLV 10 mg/m^3. Respirable Fraction: OSHA PEL 5 mg/m^3, ACGIH TLV 5 mg/m^3.
EXPOSURE ANALYSIS METHOD	NIOSH Manual of Analytical Methods, 3rd., Method 7501 (1984).

SECTION 9	SOURCE OF INFORMATION

Walter E. Kozlowski	DATE: 1/13/03

N.A. = Not applicable

Memorandum

U.S. Department
of Transportation

Federal Aviation Administration

Subject: **<u>INFORMATION</u>**: Bonded Joints and Structures - Technical Issues and Certification Considerations; PS-ACE100-2005-10038

Date: **DRAFT**

From: Acting Manager, Small Airplane Directorate, ACE-100

Reply to Attn. of: Lester Cheng; 316-946-4111

To: See Distribution

1.0 General

Many manufacturing and repair applications for aircraft structures in small airplanes, transport airplanes, rotorcraft, and propellers use bonding. Many technical issues for bonding are complex and require cross-functional teams for successful applications. Government agencies and the aircraft industry combined their adhesive bonding experiences and technical insights to gain mutual safety benefits. In 2004, the FAA conducted a survey and two workshops to benchmark industry practices for structural bonding.

In general, bonded structures may include composite-to-composite, composite-to-metal, and metal-to-metal. The nature and technical parameters that govern these three types of bonded structures are, in essence, the same or closely related. This policy statement is applicable to these three types. Both manufacturing and maintenance (repair) can use structural bonding applications.

1.1 Purposes and Scope

Building on data collected through the survey and workshops, the Small Airplane Directorate developed this policy statement. The purposes of this policy statement include: (1) to review the critical safety/technical issues, (2) to highlight some of the successful engineering practices employed in the industry, and (3) to present regulatory requirements and certification considerations pertinent to bonded structures. This policy statement also identifies some available guidance and technical resources for reference purposes. This policy statement applies to part 23 airplanes.

To achieve continued operational safety, the bonding applications require integrated considerations involving design, manufacturing and maintenance. The scope of this policy statement includes (1) material and process qualification and

Manufacturing scaling issues for a particular bonded structure need to be considered when selecting a surface preparation for bond process qualification. The substrate surface morphology and chemistry, which are created by a qualified surface preparation process, are not changed in production implementation. Since specific bonded part geometries are often more complex than specimens used for qualification, additional processing challenges exist. Some production process controls used to monitor surface preparation include visual checks, polarized light checks, water break tests, chemical analysis, and mechanical tests using samples from bonded witness panels. Once a surface is prepared, some processes rely on time constraints during bond assembly, requiring surface preparation to be repeated if the bonding operation does not occur within the specified time.

There are geometric, fit-up and other timing issues to consider in bond assembly. Cured dimensional tolerances and warpage are controlled for mating parts. Since the bondline thickness affects the local bond stress distribution and strength, it is also monitored using process checks. Assembly jigs and procedures can provide pre-bond gap assessment. Processing aids (for example, verafilm) are used to assess the tight tolerances needed for some bonding processes. Handling requirements and procedures exist to control the film adhesive lay-up process. The mixing and application of paste adhesive require additional processing steps and controls. The mixing ratios of paste adhesive constituents and filler content are controlled and monitored. Tight controls are also applied to determine the completeness of the mixing process. Depending on the type of paste adhesive used, bond assembly time constraints from adhesive mix to mated surface contact are implemented. The minimum bondline thickness can be controlled using a number of different spacer types (for example, scrim cloth, glass beads and micro balloons). The tolerances of assembly jigs are monitored and maintained over time.

The cure of bonded structures is controlled to ensure that the adhesive properly wets the substrate surfaces and dwells at temperatures needed to fully develop the properties for intended applications, without overheating. As discussed previously, the scaling issues associated with bonding large-scale airframe structures are complex. Heat transfer, bond surface contact pressure, and adhesive characteristics during different stages of the cure cycle all combine to affect the final state of the bond at local points throughout the structure. Manufacturing trials are typically needed for new combinations of parts, tooling, and equipment. Tolerances are established and in-process controls are implemented to locally manage the bond cure cycle and avoid overheating. Cure tooling and the equipment used to apply temperature to structures during bonding is controlled and maintained. Procedures used for in-process monitoring are validated and regularly calibrated.

Manufacturing quality management is important to many aspects of bonding. A combination of strict in-process controls and post-bond inspections is used. The

Audio Noise Suppression Techniques

Application Note AN-24

POWER INTEGRATIONS, INC.

Electronic and magnetic components can generate audible signals when they are excited at frequencies in the range of human hearing. This phenomenon has been observed since the early days of electric power conversion. Transformers operating at the line frequencies of 50 and 60 Hz often produce an undesirable hum. It is well known that switching power converters operating at constant ultrasonic frequencies can produce audible noise if their loads are modulated with audio frequency components.

Audio frequency signals are usually not a concern with converters that operate at low power levels. There may be applications, however, when designers will desire to reduce the acoustic emissions from their circuits. Welding the steel laminations in 50 and 60 Hz transformers reduces the hum to acceptable levels in low power AC-DC adapters. Analogous techniques are applied to ferrite transformers in high frequency switching converters.

Sophisticated audio engineering equipment has been used to study acoustic emissions from switched mode power conversion circuits. The instruments can measure absolute sound pressure levels and spectral content with great accuracy, but human perception of sound is very subjective. It is difficult to assert how much will be audible, and even more difficult to determine how much will be perceived as unacceptable noise in a given application.

Acoustic emissions are similar to electromagnetic emissions, but there are no universal standards to provide a benchmark for acoustic compatibility. Therefore, designers may wish to follow these guidelines to reduce the acoustic emissions from their products if they have any concern about audible noise.

Quick Guide for *TinySwitch*™ Designs

The ON/OFF control used in *TinySwitch* can generate audio noise in the clamp capacitor and the transformer at certain load conditions. The following simple design steps can be taken to dramatically reduce audible noise at virtually no added cost.

1. Some types of ceramic capacitors used in primary clamp circuitry can be very noisy. Replace the ceramic capacitor with a plastic film capacitor or use a Zener clamp. Zener clamps are now comparable in cost to RCD clamps, take up much less space and also provide higher efficiency. Ceramic capacitors used in RC snubbers connected to the DRAIN rarely generate audio noise (See Figure 1).

2. Construct the transformer using one of the techniques described in this application note. Gluing with glass spacer beads on all three legs is recommended because it has superior structural integrity with temperature changes, independent of the spacing between cores. This technique also eliminates the need to gap the core, saving cost. In contrast, conventional gluing (with hard glue) of center gapped cores needs to be checked over the specified temperature range for structural integrity, especially for gaps in excess of 0.1 mm. Potting is another option at a slightly higher cost.

3. If further audio noise reduction in the transformer is desired, use a lower peak flux density. Changing the peak flux density from 3000 gauss to below 2500 gauss can provide a noticeable benefit.

Capacitor Noise

All dielectric materials deform under the stress of an electric field. This electrostrictive effect is proportional to the square of the electric field intensity. Some dielectrics exhibit an additional piezoelectric effect, which is a linear displacement proportional to the electric field intensity. The piezoelectric effect is usually the dominant mechanism that produces noise from the capacitors.

The nonlinear dielectric material in ceramic capacitors typically contains a high percentage of barium titanate, which is piezoelectric at normal operating temperatures. As such, these components tend to make more noise than capacitors with linear dielectric compositions. In switching power supplies, the capacitors in the clamp circuits that see large voltage excursions are the most likely to produce audible noise.

To determine if the ceramic capacitor is a major source of noise, replace it with one having a different dielectric. Plastic film capacitors are cost effective alternatives. Take care to be sure the replacement can withstand the repetitive peak current and voltage stress.

A cost competitive option is to replace the RCD clamp circuit (Figure 1) with a Zener clamp circuit. Zener clamps are now comparable in cost to RCD clamps. They take up much less space and also provide higher efficiency.

at *www.powerint.com* gives contact information for suppliers who have demonstrated their ability to produce transformers for low audible noise. These suppliers are ready to provide samples to customers.

This document gives details of two construction techniques for reference by customers who prefer other sources of supply. Users are cautioned to perform sufficient testing to qualify all components for their intended applications.

Adhesives in Transformers

The use of adhesives in the construction of transformers is well known in the industry. Various glues, cements, coatings and potting compounds can help transformers resist mechanical shock, exclude environmental contamination, and meet safety requirements. As with each of these purposes, there are special considerations in the use of adhesives to reduce audio noise.

The adhesive should be a rigid type. The desired characteristics are most often found in hard epoxies. Soft compounds like silicone RTV are not as effective. Transformer manufacturers will often be in the best position to select an appropriate material because they usually have their own list of preferred adhesives for specific purposes that work well with their individual processes.

The chief purpose of the adhesive is to prevent relative motion between the two pieces of a magnetic core, and between the core and the bobbin. A secondary purpose is to damp mechanical resonance of the transformer structure.

Unfortunately, misapplication of adhesives can induce mechanical stresses that will fracture the core. The structural materials in transformers change dimensions by different amounts when the temperature changes. Mechanical stresses will develop if the individual pieces cannot move to compensate for these dimensional changes. Restricted motion of ferrite, bobbin, and adhesive can produce enough stress to cause the materials to fail. Also, too much or too little adhesive can result in less than optimum reduction in audio noise.

This document describes two techniques for the use of adhesives in the construction of transformers. The first method avoids the problems associated with mechanical stresses altogether. It can be used with all two-part core structures, and it offers advantages even in applications where audio noise is not a concern. The other technique is an alternative method that may be used with caution only after appropriate temperature testing of each design.

Transformers with Glass Beads

The most effective way to reduce audio noise from transformers is to glue mating surfaces of the ferrite pieces with a rigid adhesive. A uniform spacing between mating surfaces in a symmetrical structure prevents mechanical stresses because it allows the ferrite and the adhesive to change dimensions independently. One may easily achieve the desired uniformity in spacing with a mixture of adhesive and glass spacer beads.

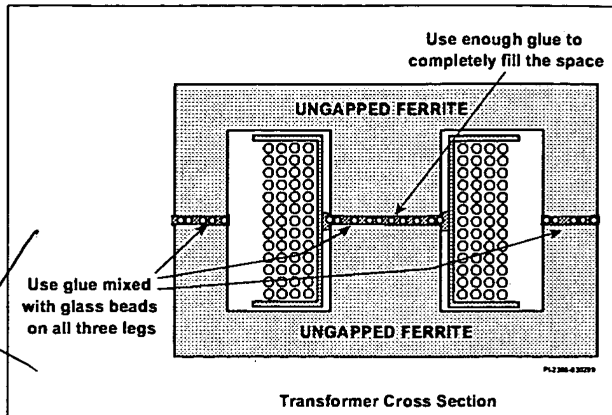

Figure 2. Construction with Glass Spacer Beads.

Figure 2 illustrates the use of glass spacer beads in the construction of a transformer with two identical E-cores. Glass spheres in the adhesive maintain uniform spacing between the pieces in each leg. This spacing maintains the appropriate nonmagnetic path length to obtain the desired inductance. The adhesive and the ferrite can expand independently by different amounts while remaining securely bonded together.

The Figure also shows that a small amount of adhesive from the gap in the center leg bonds the bobbin. It is important that the bobbin does not bond along its entire length. The construction must allow the bobbin and the core to change their dimensions independently in response to changes in temperature.

This same technique works well for EI structures also. As with the EE structure, each leg is the same length. Grinding is not required to make a gap in any leg. The glass beads in the adhesive maintain the required spacing to determine the inductance.

The procedure for design and construction of transformers with glass spacer beads is simple, straightforward and economical. The next section addresses these topics.

Design and Construction with Glass Beads

The use of glass spacer beads to define bond lines is a common industrial practice. Several manufacturers provide the materials in a variety of sizes and dimensional tolerances. The Appendix of this document gives information on common sizes and known sources of supply. While the products are likely to be screened with the same standard meshes and sieves, some suppliers may have better quality control or tighter tolerances in their products. Users are advised to check the specifications before selecting a supplier.

How to Choose the Proper Size Glass Bead

Calculations of air gap dimensions often use ideal models that assume all the flux is confined to the core. Such calculations are seldom accurate because there is always some flux that escapes from the core. Therefore, designers use the computed value of A_L (inductance per squared turn) rather than a physical dimension as a design parameter for a given core size. In Power Integrations' transformer design spreadsheet (see AN-18) this parameter is called A_{LG}.

The design procedure with glass beads is the same as for cores with center gap when only standard gap lengths are available. To design a transformer for construction with glass beads, one needs to know the A_{LG} for each core and glass bead size under consideration. The Appendix of this document gives approximate A_{LG} values for selected cores with 15 common sizes of glass beads. The transformer designer simply adjusts parameters to produce a computed A_{LG} that matches one in the table.

For experimentation, users should have sizes that are adjacent to any value they select from the table in the Appendix. Differences in processes, procedures and core composition may alter the values in the table sufficiently to require a different size bead for optimal design. Therefore, designers may wish to make their own table of A_{LG} values that are refined to match their particular process.

Assembling Transformers with Glass Beads

The best method for assembly of transformers with glass spacer beads will depend on the particular circumstances of production. For example, the optimal method for large volume production on a highly automated production line is not likely to be the best way to produce smaller quantities where most of the work is performed by hand. The major differences between the two operations are likely to be in the selection of the type of adhesive, and in the details of the mixing.

High volume automation is likely to use a two-part adhesive that cures quickly at a moderate temperature. The details of mixing the glass beads with the adhesive will depend on the characteristics of the machinery.

Lower volume production will likely use a single part adhesive with a curing schedule of about one hour at a temperature over 100 °C. The glass beads may be mixed with the adhesive just prior to use, or a suitable mixture may be purchased from the adhesive supplier.

The adhesive should be a compound of high enough viscosity to keep the glass beads in a uniformly distributed suspension. The Appendix lists some examples that are known to work well for laboratory use and for production in medium volumes. Fast curing and low viscosity adhesives like cyanoacrylate are not appropriate. The adhesive must also be rated for use at the temperature extremes of the application.

A mixture of about 10% glass beads by weight of appropriate adhesive gives good performance for most applications. Although in theory there needs to be only one bead in each leg to maintain the required spacing, there should be a sufficient number of beads in each leg to keep the mating surfaces parallel while the adhesive cures. Evaluations have shown that mixtures of less than 5% glass are likely to leave some legs without beads. More than 20% can make the mixture too stiff for reliable application and adhesion. These results may vary with adhesives that have different characteristics.

The cost of the glass beads in a transformer is negligible. An EE16 transformer needs about 20 milligrams of glue and glass mixture. If 10% of the mixture is glass, an EE16 transformer needs about 2 milligrams of glass. Assuming a worst case cost of $100 per pound ($0.22 per gram), the cost of glass beads in one transformer would be $0.00044, or 0.044 cents.

Construction Hints

There are many ways to assemble transformers with glass spacer beads. This section offers suggestions that are applicable to laboratory prototypes and small production runs.

- Make a fixture with permanent magnets to hold the transformers for gluing and curing. Start with a steel sheet or tray that will fit the curing oven. Glue button magnets to the tray in a suitably spaced array. Alternate the north-south orientations of the magnets to obtain the strongest magnetic field.
- Place one ferrite E-piece on each magnet with the legs upward. Apply a mixture of adhesive and glass beads to each leg. A disposable plastic syringe (sometimes called a transfer pipette) makes a good dispenser when constructing many transformers at one sitting.
- There must be enough adhesive in each location to completely fill the space between the two mating surfaces. Voids will allow the transformer to produce more audio noise. Be careful not to apply too much to the center leg. There should be enough extra to bind to the bobbin only at its center.
- Put the bobbin on the E-piece that has the glue. Then mate the second ferrite piece (E or I) to the first. Press the top ferrite with enough force to guarantee that only one layer of glass beads determines the separation between the two pieces.
- Place the tray with the assembled transformers in the curing oven. It is not necessary use tape or clamps. The magnets provide sufficient force to hold the pieces together.